

**Before the
Federal Communications Commission
Washington, D.C. 20554**

In the Matter of)	
Amendment of the Commission's Rules with)	GN Docket No. 12-354
Regard to Commercial Operations in the)	
3550-3650 MHz Band)	

To: The Commission

Comments of Shared Spectrum Company

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February 20, 2013

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COMMENTS OF SHARED SPECTRUM COMPANY

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SUMMARY

Shared Spectrum Company (SSC) is a leader in Dynamic Spectrum Access (DSA) radio technology, And as such SSC has been involved in practically every spectrum sharing initiative of the NTIA, FCC, and the Administration.

SSC applauds the Commission for proposing sharing of the 3.5 GHz band. SSC believes that increasing access to unused federal spectrum is essential to the development of a robust, competitive mobile broadband marketplace, and that most of this 3.5 GHz band is, in fact, available for the deployment of new services.

SSC believes that, in the short term, a geo-location database, augmented with sensing technology at the system location, will, as a practical matter, result in much smaller exclusion zones, albeit not eliminating them entirely.

In order to maximize the use of the 3.5 GHz band, SSC advocates a longer-term approach, in which sensing-only devices are permitted to be deployed in the band by new services. These sensing-only devices would be smart enough to recognize channel usage by incumbents and find alternatives, or else not transmit.

SSC supports combining the lower half of the 3.5 GHz band with the upper 3.5 GHz band, as proposed by the Commission.

SSC attaches a draft report of the CSMAC subcommittee on spectrum sharing to illustrate the benefits of the various sharing approaches, especially the sensing-only approach.

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Shared Spectrum Company (SSC) hereby submits its comments in the above referenced proceeding in response to the Notice of Proposed Rule Making, FCC 12-148, released December 12, 2012 (NPRM).

I. INTRODUCTION:

Shared Spectrum Company (SSC) is a leader in developing spectrum sharing technologies, including Dynamic Spectrum Access (DSA) radios, frequency sensors, and related software applications. Founded in 2000, SSC is a small, entrepreneurial business that has been inventing and implementing a broad range of innovative capabilities that enable wireless devices to share various frequency bands for a multitude of applications.

For example, the company developed DSA over the past 12 years on several military projects, building prototype devices, and developing software. SSC performed successful DSA radio tests at Fort A.P. Hill, Virginia, demonstrating core spectrum access principals of the Defense Advanced Research Projects Agency (DARPA) NeXt Generation (XG) Communications program.¹

¹ See Mark McHenry, Eugene Livsics, Thao Nguyen & Nivedita Majumdar, "XG Dynamic Spectrum Access Field Test Results," IEEE Communications Magazine, Vol. 45, no. 6, pp. 51-57 (June 2007), available at <http://www.sharespectrum.com/wp->

In addition, SSC has been a leading voice in favor of spectrum sharing at the Federal Communications Commission (FCC), with the National Telecommunications and Information Administration (NTIA), and before decision-makers in Congress and within the Administration. For example, SSC filed extensive Comments and Reply Comments in the FCC's Notice of Inquiry concerning use of DSA technology.² There, SSC urged the Commission to: (1) develop a policy-based regulatory framework for spectrum sharing across multiple spectrum bands; and (2) propose spectrum sharing rules for Federal spectrum bands that take into account incumbent requirements and incentives.³

Our history of involvement in the TV White Spaces (TVWS) rulemaking provides us with particularly relevant insights for how the Commission should proceed to open the 3.5 GHz band to shared uses. Indeed, since its founding, SSC has been a vigorous supporter of efforts to increase spectrum utilization through the deployment of sharing technologies, both before the Commission and in similar proceedings conducted by the NTIA and other federal government forums. For example, SSC is a major contributor to the CSMAC Working Group 4 Subcommittee on federal spectrum sharing. Attached hereto as Exhibit A is a draft Report from that Subcommittee that illustrates the types of sharing concepts being considered by the Department of Defense and industry stakeholders.

content/uploads/2007-02_SSC_Description_Demonstrations_Ft_AP_Hill.pdf.

² Promoting More Efficient Use of Spectrum Through Dynamic Spectrum Use Technologies, *Notice of Inquiry*, ET Docket No. 10-237, 25 FCC Rcd 13711 (Nov. 30, 2010) ("*DSA NOI*").

³ See Shared Spectrum Company Comments, ET Docket No. 10-237, at 20-21 (filed Feb. 28, 2011).

In addition, SSC was highly engaged in the development of the July 20, 2012 Report by the President's Council of Advisors on Science and Technology on Spectrum Technology (the PCAST Report).⁴ The PCAST Report specifically concluded that, "The norm for spectrum use should be sharing, not exclusivity," noting that a new spectrum architecture and a corresponding shift in practices could greatly multiply the effective capacity of spectrum.⁵

It is against this background of development of spectrum sharing technology and promotion of policies for deployment of such leading-edge technology that SSC welcomes the opportunity to comment on the issues raised by the NPRM.

I. EXCLUSION ZONES CAN BE REDUCED IN SIZE AND ELIMINATED OVER TIME

As the Commission and NTIA both note, the 3.5 GHz Band seems ideal for shared federal and non-federal use.⁶ Incumbent uses in the band include high-powered Department of Defense (DoD) radars⁷ as well as non-federal Fixed Satellite Service (FSS) earth stations for receive-only, space-to-earth operations and feeder

⁴ President's Council of Advisors on Science and Technology, "Realizing the Full Potential of Government-Held Spectrum to Spur Economic Growth," (rel. July 20, 2012), available at <http://www.whitehouse.gov/administration/eop/ostp/pcast/docsreports>.

⁵ *Id.*, at vi.

⁶ See NTIA, An Assessment of the Near-Term Viability of Accommodating Wireless Broadband Systems in the 1675-1710 MHz, 1755-1780 MHz, 3500-3650 MHz, 4200-4220 MHz, and 4380-4400 MHz Bands (rel. October 2010) ("Fast Track Report"), available at http://www.ntia.doc.gov/files/ntia/publications/fasttrackevaluation_11152010.pdf, at v, 1-6; Enabling Innovative Small Cell Use In 3.5 GHz Band, *Notice of Proposed Rulemaking*, GN Docket No. 12-354, 27 FCC Rcd 15594 (Dec. 12, 2012) ("NPRM") at ¶6.

⁷ There are many types of military radars operating in the 3.5 GHz Band (*e.g.*, shipborne, groundbased, etc.). For purposes of the NPRM, the term "DoD radar" refers generally to all of the radar systems in the 3.5 GHz Band. The term "Navy radar" refers only to shipborne radars operating in the 3.5 GHz Band. Other specific radar systems (*e.g.* "DoD ground-based radar") are specifically referenced as necessary.

links.⁸

The Commission observes in paragraph 6 of the NPRM that it agrees with the PCAST Report's suggestion (at pp.16-21 and 82-84 thereof) that smaller cells, rather than macrocells, could be useful for sharing in the 3.5GHz band. However, based on NTIA's Fast Track Report, the FCC estimates in footnote 12 of the NPRM that, for purposes of sharing with high-powered WiMax technology in the 3.5 GHz band, up to 60% of the population of the United States would be within an exclusion zone, and therefore would not have access to such WiMax operations. At paragraph 7 of the NPRM, the FCC seeks comment "on whether the use of small cell technology incorporating lower power levels and other distinguishing technical characteristics compared to higher power cellular architecture systems could significantly reduce the exclusion zones proposed in NTIA's Fast Track Report."

SSC believes that small cell technology operating at lower power levels, or with other technical characteristics, such as sensing capabilities, could significantly reduce the size of the exclusion zones. Sensing capabilities in particular could be useful here, because there appears to be little use of the band in some areas within the exclusion zone. For example, in measurements performed at SSC's spectrum observatory in Vienna, VA, over a period of 9 days, there was only one use of that band, and that lasted for less than 10 seconds. While spectrum measurements throughout the exclusion zone over longer periods of time would help establish the

⁸ Fast Track Report at 3-30 – 3-33.

true utilization of this band, the fact that so little usage was measured in the Washington, DC area indicates the value of using sensing technologies to determine when this spectrum can be shared, even within the exclusion zones.

SSC's Dynamic Spectrum Access (DSA) technology framework offers an embedded, turn-key software solution for enabling advanced frequency agility and spectrum sharing on existing and future software defined radio (SDR) platforms. This framework combines advanced, policy-based spectrum sensing and signal classification algorithms, network collaboration protocols, and efficient data fusion and management tools. It uses extensible, standardized rule-based language and reasoning to rapidly establish, maintain, and adjust radio and network parameters to improve performance in the presence of a variety of incumbent or legacy radio networks and radar systems. The key features of SSC's DSA system include the following:

- (1) A fast embedded database for capturing, fusing, maintaining, and querying up-to-date and historical information on the surrounding spectrum environment as reported by local host and connected peers;

- (2) Efficient high-level and low-level spectrum sensing scheduling algorithms, distributed coordination protocols, collection protocols, and intelligent waveform application coordination techniques for collecting real-time spectrum use information;

- (3) Basic and advanced algorithms for classifying various types of narrowband, wideband and waveform-specific signals;

- (4) A rule-based policy processing engine for dynamically restricting transmission frequencies, power levels, modulation and other transceiver and antenna configurations based on, for example, time of the day, location, sensing results, and device/network capabilities;

- (5) Advanced rendezvous protocols for establishing networks and

rapidly joining, merging or splitting active DSA-enabled radio networks to meet coverage, capacity and coexistence needs;

(6) Sophisticated group coordination protocols for localized and network-wide link transition planning and execution;

(7) Logging, reporting and querying protocols to collect and fuse data for radio environment mapping; and

(8) A modular software architecture and APIs that are operating system, processor and waveform agnostic.

All of DSA's benefits could come to bear in the 3.5 GHz band, over time, to permit true, nationwide sharing of this valuable spectrum between military and other incumbents and entrants. Exclusion zones could be reduced and, ultimately, eliminated entirely, as DSA technology is more widely deployed.

In particular, SSC advocates a two-phase approach. In the near-term, SSC supports the adoption of a hybrid regulatory structure that utilizes database and sensing techniques to minimize the exclusion zones. Over the longer-term, SSC believes that exclusion zones can be eliminated entirely with the implementation of DSA or similar sensing technologies into all end user devices in the 3.5 GHz band. This sensing-only approach is the best method for sharing with military incumbents, who typically are unwilling (or, at the very least, highly reluctant) to divulge either their location, or the extent of their communications, to a database operator.

II. COMPARING THE VARIOUS SHARING MODELS

The approaches we describe below are based on various features of SSC's DSA technology and software, which can be implemented through: (1) a geolocation

database approach with advanced data fusion capabilities; (2) sensing-based methods using stand-alone networks, on-board sensing or off-board sensing; and (3) a hybrid system architecture that combines aspects of those two approaches. Please refer to the diagrams in the draft CSMAC Report, attached as Exhibit A, for a depiction of how these scenarios might be deployed.⁹

A. Geo-location Database Approach

The FCC has issued rules for using competitive geolocation databases to enable access to the television broadcast bands by unlicensed, low power devices. However, in federal frequency bands, such as the 3.5 GHz band, the various federal incumbents are highly unlikely to provide sufficient information (*e.g.*, location and operating frequency) about their operations (especially with respect to military uses) that would be necessary to accurately populate such databases. Such operations are also likely to involve shipboard, airborne and other mobile operations that cannot be accurately captured in a database.

Accordingly, a stand-alone geolocation/database approach would not likely yield significant spectrum capacity or coverage for new entrants, especially if large geographic exclusion zones are the result of information gaps. On the other hand, a database approach may be attractive to new entrants in the short term, if minimal system modifications are required and adequate coverage/capacity can be achieved

⁹ As a preliminary matter, it is important to note that the received incumbent signal power at the DSA receiver, subtracted from an assumed incumbent transmit power value, is the entrant-to-incumbent propagation-loss value. Sensing is a key part of our recommended approach because sensing directly measures this entrant-to-incumbent propagation-loss value.

in certain areas and bands.

B. Sensor Network Approach

In this option, a network of interoperable DSA-enabled radios acquires contextual information about the regional spectrum environment by querying a stand-alone external sensor network. The sensors are located near the legacy system locations. Insufficient densities or uneven sensor distributions can result in a higher likelihood of false positive readings, or a flawed conclusion as to the existence of a spectrum “hole.” Therefore, some sort of control channel or “cognitive pilot channel” is assumed.

One of the key advantages of this approach is to simplify the entrant radios, which would result in reductions in cost and energy consumption. It also improves the availability of spectrum due to superior local knowledge when compared to a stand-alone geolocation database approach.

C. Off-Board Sensing Approach

In this scenario, off-board sensors are co-located with, or integrated into, the entrant’s network base stations. Standardized or separate proprietary sensors are used that incorporate technical methods to “look through” the entrant system’s co-channel interference to detect the weak legacy signals. They sense the local spectrum environment with improved coverage density and distribution, thereby reducing incorrect spectrum-availability decisions.

Since these sensors are within close proximity to, and operate in conjunction with, the end user devices, they provide better local spectrum environment information when compared to the previous two approaches. Therefore, the principal advantage of this approach is increased spectrum availability for the entrant system because of less uncertainty in determining the propagation losses between protected emitters and the broadband system base stations.

However, the “look through” method might not provide enough detection sensitivity for interference free operation. Another potential disadvantage of this approach, if proprietary software solutions are used, is the non-recurring development and testing costs required for full DSA integration into the base station radio.

A short-term solution involves a co-located, non-integrated hardware/software sensor, which also adds to the incremental costs. This method also could also be more difficult and costly to implement for ad hoc and low-power networks that have no fixed infrastructure.

D. On-Board Sensing Approach

In this alternative, all or a large number of interoperable DSA-enabled end user radio devices sense the RF environment directly and make operational decisions based on those inputs as well as information gathered from neighboring,

collaborative devices. The on-board sensors integrate coordinated sensing periods into the entrant waveform, measure the signal power of incumbent transmitters, and share these measurement results with other DSA-enabled radios.

The greatest advantage of this approach is that it provides the maximum spectrum availability in terms of capacity and coverage for entrant systems because of the minimal uncertainty in determining propagation losses between the incumbent systems and the device itself. Thus, the need for exclusion zones and databases in the 3.5 GHz band could be entirely eliminated if all entrant devices have on-board sensors.

In this approach, there are little or no extra hardware costs. All of the DSA functionality is in the software installed on existing Commercial-off-the-Shelf (COTS) chipsets or, in the long run, in firmware on DSA-enabled Application Specific Integrated Circuits (ASIC) built into the end-user devices.

A main disadvantage for short-term prospects under this approach is that non-recurring software and API development and testing is necessary to fully integrate the DSA software in end-user devices. In addition, although some DSA concepts (such as using the Received Signal Strength Indicator (RSSI) to select the operating frequency) are in the Long Term Evolution (LTE) and other standards, further DSA standards development must continue. In light of the current lack of standards for embedding full DSA functionalities, together with the initial cost of

upgrading end-user devices, this approach may be of less interest to service providers and manufacturers in the near-term. Nevertheless, the preferred, long-term commercialization approach would lead to wide-spread development and deployment of DSA-enabled end user devices with on-board sensing capabilities.

E. Hybrid Approach

Under this final approach, a combination of the above techniques is used to address short-term cost and performance concerns. For example, geo-location databases with off-board sensing could be implemented in the short term, provided that any end user devices must be capable of flash programming so that future on-board sensing upgrades could be remotely installed. Such an approach would eventually lead to a sensing-only regime as the preferred approach to sharing with military and other incumbent users in this, and perhaps other, bands.

III. SENSING-ONLY OPERATIONS SHOULD CONTINUE TO BE ENCOURAGED.

In paragraph 7 of the NPRM, the FCC proposes to create “a Citizens Broadband Service, managed by a spectrum access system (SAS) incorporating a dynamic database and, potentially, other interference mitigation techniques.” The Commission in paragraph 10 of its NPRM further states that General Authorized Access (GAA) “users be required to register in the SAS and comply with all applicable technical, regulatory, and enforcement rules to ensure that GAA users avoid causing harmful interference to Incumbent Access and Priority Access users and always accept harmful interference from such users.”

Additionally, the Commission states that:

No Citizens Broadband Service device would be permitted to operate at any power level without registering in the database and providing accurate location information. The database would assign available spectrum to Citizens Broadband Service devices in a manner that ensures that such devices would not interfere with existing radar or satellite earth station operations.¹⁰

SSC suggests that, as a general rule of thumb, whenever it seeks to adopt sharing rules for new spectrum bands, the Commission should keep open the option for utilizing sensing-only technologies, in addition to the option for using a database, to determine channel availability. In the TVWS proceeding, for example, the Commission permitted, but did not require, sensing-only as a path forward.¹¹ SSC recommends that the Commission adopt this approach in the instant proceeding, permitting a sensing-only capability as one option for users, as well as the separate, database approach.

In paragraph 10 of its NPRM, the Commission seeks “comment on what technologies could be used to enable effective GAA use of the 3.5 GHz Band.” As SSC has noted previously in other spectrum sharing rulemakings (including the proceedings involving the TVWS, Incentive Auctions, and the 4.9 GHz band), sensing technology would enable effective sharing of spectrum between licensed incumbent operators and secondary, lower power users such as, in this case, GAA users.

¹⁰ NPRM at ¶ 96.

¹¹ See 47 CFR §15.717.

As the Commission notes in paragraph 41 of the NPRM, the PCAST Report supported the development of sharing regimes with third tier users (e.g., GAA) that would be entitled to use the spectrum on an opportunistic basis and would not be entitled to interference protection. The PCAST Report stated that devices in this tier “should be capable of operating on multiple frequencies and should incorporate spectrum sensing and other cognitive radio features to prevent harmful interference to other users.”¹² A sensing-only regulatory regime would facilitate low-power operations, consistent with that goal.

IV. AN OPTIONAL DATABASE-PLUS-SENSING APPROACH SHOULD BE PERMITTED.

In paragraph 58 of the NPRM, the FCC proposes to adopt a TVWS-style database, but to incorporate aspects of spectrum sensing and other techniques into the regulations. The FCC notes in footnote 134 of the NPRM that this type of approach is supported by the PCAST Report.¹³

SSC also embraces this hybrid, database-plus-sensing approach (while, as noted above, also encouraging sensing as a stand-alone capability for devices with the

¹² PCAST Report at 23-24.

¹³ Id. at 22-23. The Commission notes “PCAST proposes that interactions among users of the three access tiers be governed by comprehensive access system comprised of geo-location databases, sensing technologies, signal beacons, and access rules administered by the Commission and NTIA.”

proper limitations on power). A hybrid, short term database-plus-sensing approach would greatly reduce the size of the exclusion zones. In a database-only scenario, a large area of geography would remain off-limits for the foreseeable future. For example, in the area around Norfolk, Virginia, several channels might remain off-limits, essentially forever. Rather than placing 60% of the US population outside the reach of a new 3.5 GHz band service, a database-plus-sensing regime, coupled with the small cell approach, could open up the 3.5 GHz band to much more of the US population.

In the database-plus-sensing scenario, the area around Norfolk is not *per se* off-limits. A radio operating in this area will be instructed as to which channels are in use and automatically find other channels to accommodate the needed communication pathway. The lower power system will use sensing as a backup, to be certain to avoid those channels actually in use by others, including the military, in a particular location. If no channels in the lower 3.5 GHz band are available in Norfolk at a given point in time, the radio will be able to reference the upper portion of the 3.5 GHz band, which was not allocated to military use in the first place.

V. COMBINING THE TWO BANDS MAKES SENSE.

In paragraph 12, the Commission proposes to add the 3650-3700 MHz band to the regulatory regime adopted in this rulemaking for the 3550-3650 MHz band. This would enlarge the use of spectrum by GAA users in particular, and would allow

higher power operation in that portion of the band located in areas away from the 3 fixed, incumbent locations.

VI. Interference Mitigation and Sensing

The Commission in paragraphs 148 and 149 of the NPRM asks whether spectrum sensing could be used to mitigate potential interference; the Commission recognizes that:

Spectrum sensing devices employ a mechanism that detects the presence of radar signals and dynamically guides a transmitter to switch to another channel whenever a particular condition is met. Using this approach, prior to initiating a transmission, a device's spectrum sensing mechanism would monitor the available radar or small cell channel in a predefined band. If a signal is detected, the channel associated with that signal would either be vacated and/or flagged as unavailable for use by the small cell device. Spectrum sensing features (also known as "dynamic frequency selection") are currently employed in 5250-5350 MHz and 5470-5725 MHz unlicensed bands.¹⁴ We believe that similar spectrum sensing technologies could be integrated into transmitters and receivers in the 3.5 GHz Band to prevent harmful interference between the various tiers of users in a wide variety of use cases. How should the use of such technologies affect our analysis of Incumbent Use Zones? What are the advantages and disadvantages of utilizing spectrum sensing technology in a small cell environment? What are the costs associated with incorporating spectrum sensing technology into devices in the 3.5 GHz Band? Is this technology commercially available? If not, how long would it take for this equipment to become widely available on the market?

As SSC explains above, spectrum sensing is definitely a means to lessen the possibility of interference. Sensing in combination with a database model makes the database information more accurate. A device can report information back to the

¹⁴ See 47 C.F.R. § 15.407(h)(2).

database, which can in turn update its view of the quality and availability of that channel at that time and location.

Moreover, sensing as a stand-alone capability can eliminate many of the concerns often expressed regarding having to include classified information in a database. The system will sense that a particular channel is unavailable; no further inquiry is needed. In a small cell environment, sensing permits greater reuse of spectrum, especially spectrum that otherwise might have been subject to a geographic exclusion zone.

Spectrum sensing technology is largely available off-the-shelf; there are no great barriers in terms of technical or cost considerations. SSC has been offering these types of solutions for years. The technology is commercially available.

CONCLUSION

SSC believes that the Commission should adopt a short term Hybrid Approach in which geo-location databases and sensing operate together to reduce the size of the exclusion zones, while fully protecting incumbent operators. SSC believes that all end user devices should be capable of being upgraded to on-board sensing capability through software upgrades, so that over the next few years, the Commission can eliminate the need for either databases or exclusion zones in this band.

Therefore, SSC requests that the Commission incorporate into its new rules provisions encouraging the use of state-of-the-art spectrum sensing technologies consistent with the foregoing discussion.

Respectfully submitted,

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Exhibit A

Potential Spectrum Sharing Approaches

CSMAC Spectrum Sharing Sub-Committee

October 26, 2011

This material is preliminary and for discussion purposes only. None of the material here is a final recommendation or conclusion from the sub-committee.

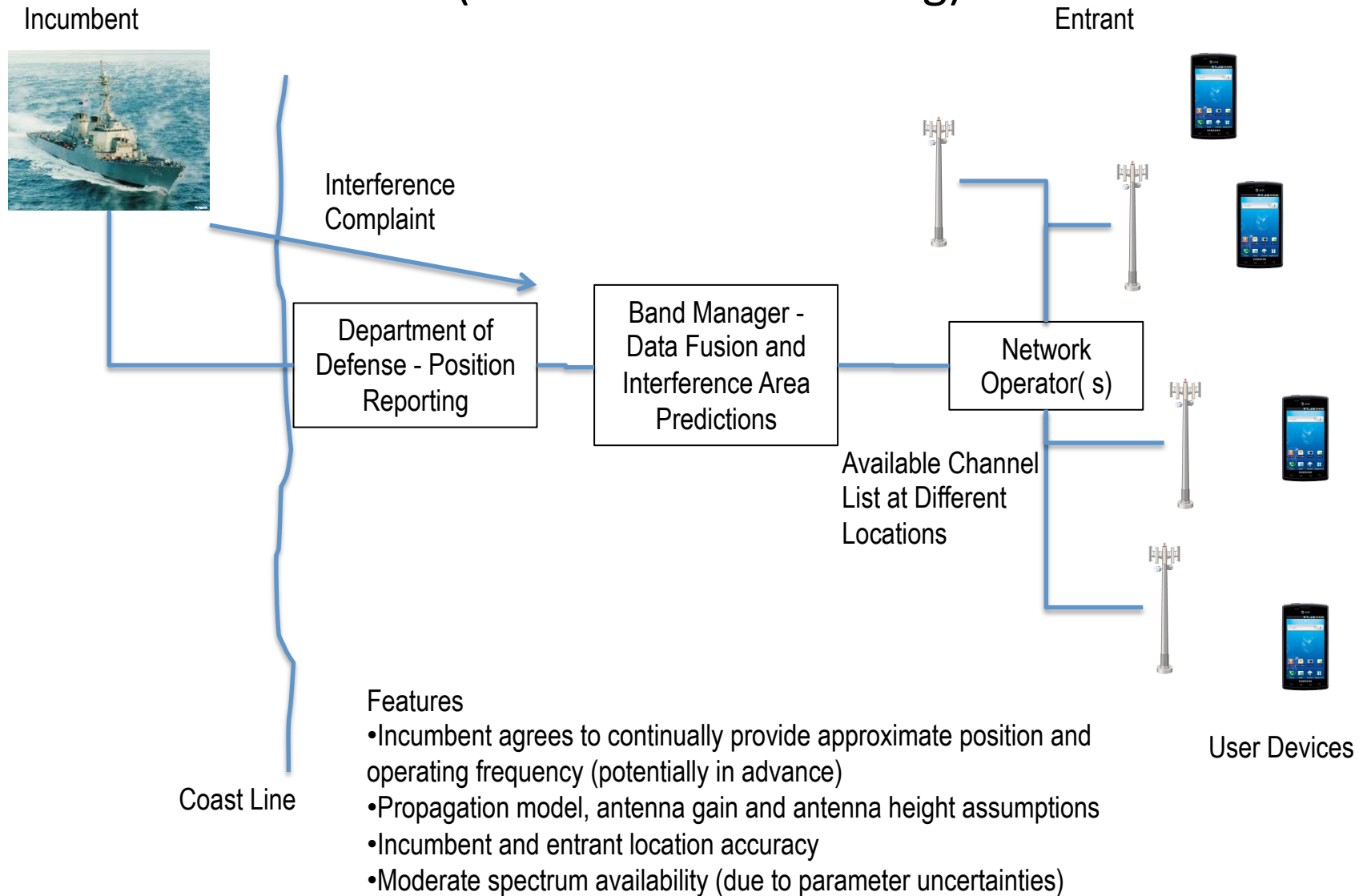
Alternate Spectrum Sharing Approaches

- Geo-Location method used to determine the transceiver parameters/capabilities (e.g., transmits frequency and power level, bandwidth, receiver capabilities).
 - Exact position vs. approximate position
 - User entered position versus GPS position versus trusted source for position
- Sensing-based method used to determine the transceiver parameters/capabilities.
 - Sensing on all entrant radios
 - Sensing on some entrant radios
 - Sensing at certain locations
 - External sensing network
 - Collaborative entrant sensing
- Combined sensing and geo-location methods used to determine the transmitted transceiver parameters/capabilities.
- Physical layer
 - Receiver ignores interference
 - Transmit modulation (UWB)
- Timesharing
 - Entrant and Incumbent share information to share spectrum in time
 - Entrant senses channel and stops transmitting rapidly when the Incumbent begins transmitting, so as not to interfere with Incumbent communication

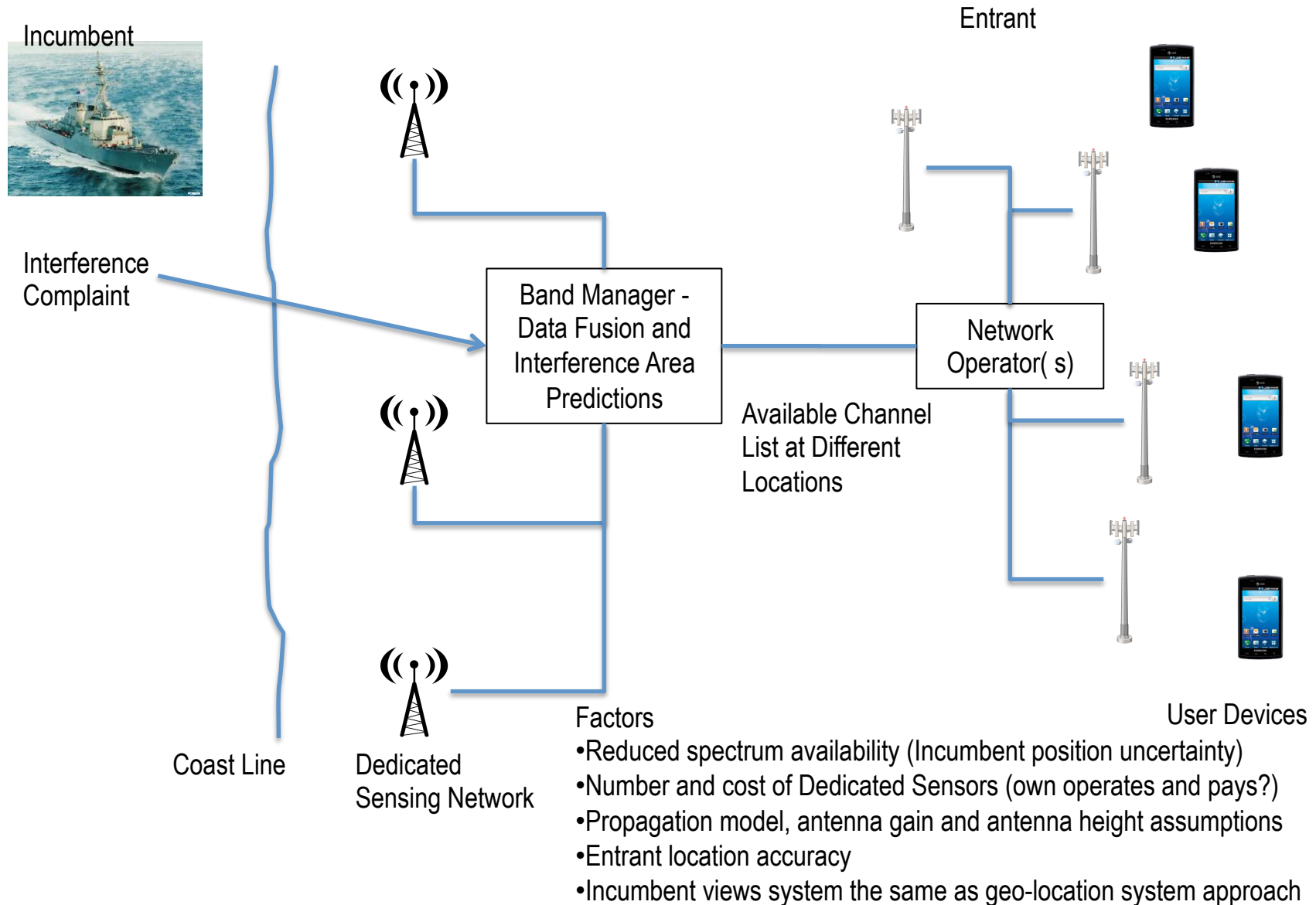
Spectrum Sharing System Approach

- Estimate propagation loss between entrant and incumbent systems
- Determine entrant operating frequencies for Do No Harm based on the above propagation losses
- Respond to incumbent's interference complaints

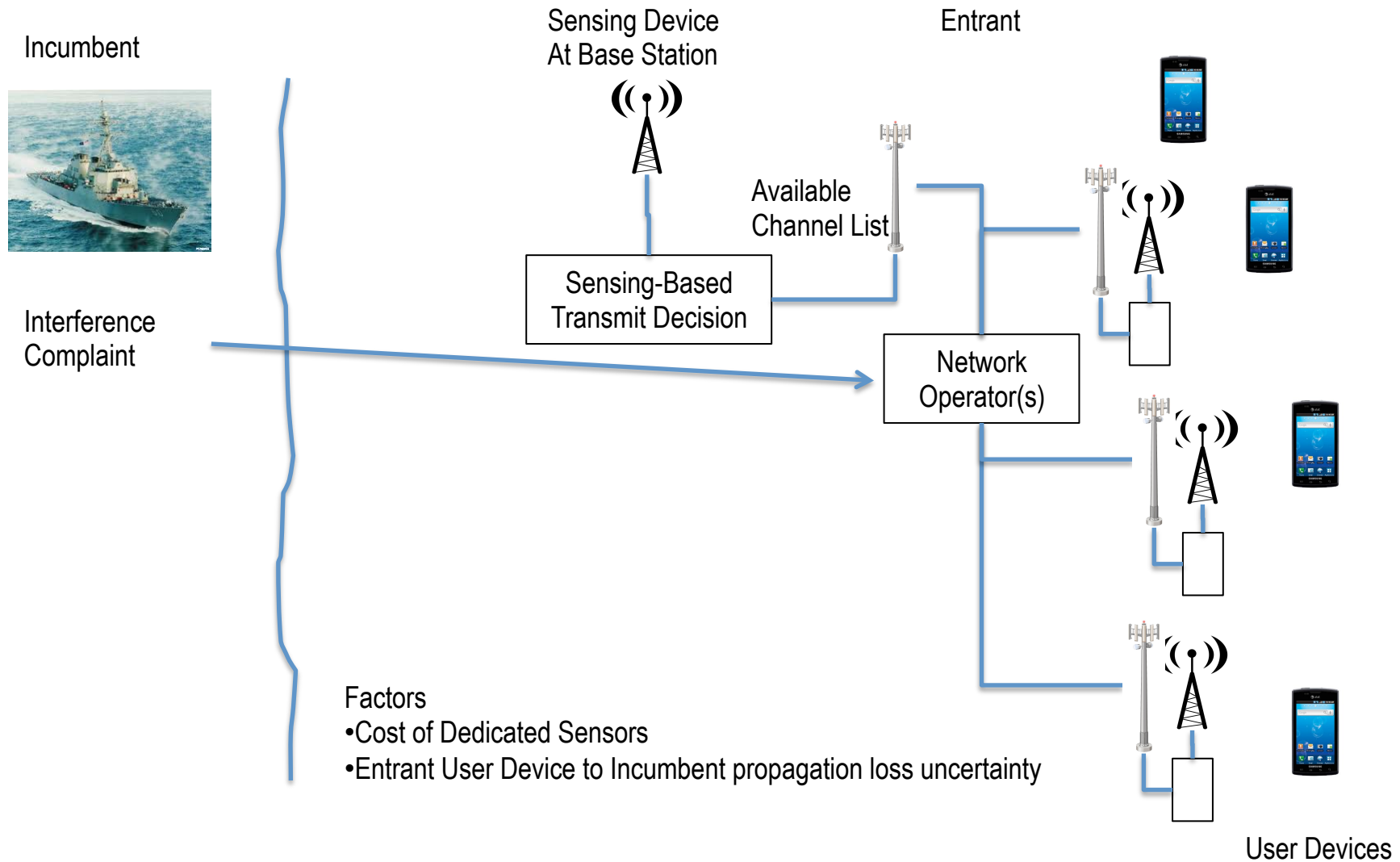
System #1 - Geo-location System (Same As Time Sharing)



System #2 – External Sensing Network System



System #3 – Sensing on Some Entrant Radios System



System #4 – Sensing on All Entrant Radios System

